INAUGURAL LECTURE SERIES 220

SPACE APPLICATIONS AND ECOLOGICAL HAEMORRHAGE: THE NIGERIAN EXPERIENCE

By

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INTRODUCTION

Mr. Vice Chancellor Sir, my distinguished audience, I stand here today as a debtor before God, to deliver the first Inaugural Lecture from the Institute of Ecology and Environmental Studies of this University. Going down the memory lane, the Institute started as a Sub-Department of Geography in 1976 under the leadership of Prof. J. O. Adejuwon. It became a full fledged autonomous Institute in 1982 with Prof. A. M. A. Imevbore as the pioneer Director. I was opportuned to be the first home-grown Director of the Institute and today a new page is being written in the history of the Institute with this August assembly, gathering to listen to this Lecture. Indeed, the wood of the Institute has begun to prepare or cook its meal. Many thanks for the labour of all the world renowned scholars who came from various departments to pilot the affairs of the Institute in the times past. The Institute has come a long way and has become a pride to the University, and a beacon of excellence to Nigeria, Africa and the whole world!

QUEST FOR SPACE EXPLORATION

The quest for space exploration may be as old as humankind. Available evidence shows that centuries before Christ, men had been dreaming of leaving the planet Earth and exploring other worlds. However, the first documented evidence of articulated need for space exploration could be traced to the ancient Greek philosopher named Socrates (469-399 B.C.). He was the one who first noted that “man must rise above the Earth to the top of the atmosphere and beyond, for only thus will he fully understand the world in which he lives”. No effort was made by man
to respond to the challenge posed by Socrates until twentieth Century when the era of space exploration officially began with the launch of the Soviet Union's Sputnik-1 on October 4, 1957. This 60-cm-diameter-sphere satellite weighed 83 kg, circled Earth once in every 96 minutes and transmitted radio signals that could be received on earth; providing the first space views of our planet. This was quickly followed, four months after, by Explorer-1 that was launched by the United States on January 31, 1958 through the U.S. Army Ballistic Missile Agency, using its Jupiter C as rocket. With the consent of the British colonial authority, USA established a portable radio tracking station in Nigeria for the purpose of tracking the progress of Explorer-1 while in space. Thus, Nigeria was inadvertently drawn into the space race before independence.

Soviet cosmonaut Lt. Yuri Gagarin became the first human that went into space in 1961 for a total duration of 108 minutes. When the USSR succeeded in putting the first human into space, U.S.A. in the characteristic competitive spirit of the cold war era, responded with Alan Shepard's Mercury flight on May 5, 1961. And twenty days after this feat, President J.F. Kennedy met the U.S congress and gave a Presidential marching order: “I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the Earth.” Thus Apollo programme was born. Unfortunately, all the crew members were killed by a fire incident on January 27, 1967 while training. But the mission continued thereafter. Also, President Kennedy never lived to see the fulfillment of this dream just like Martin Luther King Jr. never lived to see the first black man occupying the White House. Eventually, on July 20, 1969, Astronaut Neil Armstrong took “a giant step for mankind” as he stepped onto the moon. Since then,
the race to the space has heightened and many breakthroughs have been recorded in space exploration with spin-offs for environmental applications and ecological studies.

It is clear from this brief history of space adventure that space exploration was initially dominated by the then USSR and U.S.A. for possible offensive uses during the cold war. This however changed after the collapse of the USSR in 1991. The cessation of hostilities ushered in an era of cooperation in space exploration between Russia, (the leading country that emerged from the ruins of the Soviet Union), and the U.S.A. The paradigm shift made it possible to concentrate on dealing with the challenges of space mission.

Of significant importance is the development of Earth Observation Satellites (EOS), the first of which was in 1972. EOS are satellites specifically designed to obtain data about the earth while in orbit. They are intended for non-military applications and may be classified according to their orbit, height, size and payload such as macro, micro, mini-micro or nano satellites. Since the development of earth observation satellite technology in 1970s, the available sensors have been increasing both in number and sophistication.

Mr. Vice Chancellor Sir, I must say that the development of Disaster Monitoring Constellation (DMC) satellites in the 21st century, heralds a novel north-south mutualistic (rather than parasitic) co-operation in space applications for ecological studies and disaster management. The objective of this type of satellites is to provide a daily global coverage with a constellation of 5 low-cost micro satellites at a medium spatial resolution.
of 30-40m. This collaboration involves Algeria, China, Nigeria, Thailand, Turkey, United Kingdom and Vietnam and has led to the launching of some satellites, either owned or purchased by African countries. This has ameliorated problems such as prohibitive costs of image data source and lateness in arrival of such data for near real-time ecological monitoring and disaster management. The development now affords us the opportunity of rapid response with respect to ecological disasters such as erosion, flooding, forest fires, landslides, tsunamis, earthquake, and oil spill. These disasters can now be better managed and monitored using space technology.

The launching of Nigeriasat-1 satellite in 2003 constitutes a watershed of history; signifying a major scientific and technological achievement. This has propelled Nigeria into the space club, and moved the country from a sensed to sensing nation. NigeriaSat-2, if implemented as proposed, with 2.5m panchromatic, 5m and 32m multi spectral in 4 bands, will offer far higher benefits in terms of disaster management, ecological/environmental monitoring and applications for socio-economic development.

**ECOLOGY AS A FIELD OF SCIENCE**

The science of ecology is generally viewed as a discipline which studies interactions between individual organisms or systems and their environments. It was originally defined as "the comprehensive science of the relationship of the organism to the environment" (Haeckel, 1866). This marks out ecology as a multidisciplinary field in which all players are welcome. Although it was initially viewed as a branch of biology,
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A FIELD OF SCIENCE

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to the environment” (Haeckel, 1866).
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dy viewed as a branch of biology, its
development as holistic science meant that biology has in essence become
one of the sub-disciplines contributing to ecological knowledge
(Ulanowicz, 1997; Weber, 1999; Begon et. al., 2006). In common
parlance, ecology is often used as a synonym for the natural environment,
probably because both ecology and environmentalism share the holistic
view of nature.

Community, population, and ecosystem ecology have received the major
attention, even though ecology involves a wide variety of sub-fields. If we
stack all the fields of knowledge in horizontal layers like slices of bread,
ecology will represent a vertical piece cut across these layers. Ecology, in
essence, therefore, contains a bit of almost every field of knowledge. This
has necessitated the development of various branches of ecology such as
forest ecology, soil ecology, agro-ecology, microbial ecology, human
ecology and even political ecology, which links both politics and economy
to the problems of environmental control and ecological change.
Therefore, ecology is regarded as one word that basically describes the
synergism in nature - everything is related to everything else. It will
therefore amount to delusion of grandeur or mental masturbation for
anyone to claim expertise in all fields of ecology. Therefore, this lecture
will focus on a tiny bit of ecology that I know, and in which I have been
actively engaged for about a quarter of a century.

SPACE APPLICATIONS, GIS MAGIC BOX
AND ECOLOGICAL ASSESSMENT

Ecology, as a scientific discipline, is noted to have undergone tremendous
growth as well as diversification within the last century due to
technological, sociological, environmental and political developments. Specifically in 1990s, scaling theory became a major concept in ecology and remote sensing has served as a catalyst in advancement of this concept (Cohen and Goward, 2004). Beginning with the launch of Earth Resources Observation Satellite (ERTS), now known as Landsat, in 1972 and subsequently, other earth observation satellites; remote sensing has continued to provide long-running systematically collected data for ecological assessment, monitoring and management.

Prior to the emergence of the first earth observation satellite, some scientists (e.g. Birth and Mcvey, 1968) had been working on developing turf color index based on a ratio of Near Infrared (NIR) at 750 nm to red (650 nm) reflectance while others (such as Jordan, 1969) laboured to relate the quality of light on forest floor to the leaf area index (LAI). Satellite remote sensing has now led to the development of NIR-red ratio as one of the spectral vegetation indices (SVIs). These SVIs are currently at the heart of ecological applications of remote sensing (Tian and Min, 1998; Cohen and Goward, 2004). Today, the phenology of various vegetation types could be monitored with SVI. Also, soil spectral properties (Blair and Baumgardner, 1977; Crist and Cicone, 1984) are being assessed using “tasseled cap” concept; forest succession is evaluated by geometric-optical model of forest structure (Li and Strahler, 1985); while wildlife habitat, invasive species, deforestation, surface temperature, soil carbon content, biomass, Net Primary Productivity (NPP) and tropical carbon fluxes are estimated by remote sensing methods (see Hansen, et. al., 2002; Holified et. al., 2003, Salami, 2006a; 2008a). All these point to the fact that remote sensing has been at the centre of spatial and temporal studies in the field of ecology.
Environmental and political developments. It became a major concept in ecology study, with the launch of Earth Resources Observation System, known as Landsat, in 1972 and advanced remote sensing; remote sensing has significantly contributed to the systematic collection of data for environmental and management.

The first Earth observation satellite, some 1968, had been working on developing Near Infrared (NIR) at 750 nm to red (such as Jordan, 1969) to the development of NIR-red ratio indices (SVIs). These SVIs are currently at the cutting edge of remote sensing (Tian and Min, 1998; Tian, 1998b, the phenology of various vegetation. Also, soil spectral properties (Blair and Morgen, 1984) are being assessed using various successions evaluated; the role of spatial structure on the dynamics of communities, population, and ecosystems. These were usually represented within spatial ecology, as entities having spatial relations with one another, besides the traditional ecological relations defined by their interactions (Kerr and Østrov, 2003).

GIS took place about the same time with the advent of space exploration and the two have since been linked together. GIS emerged in Canada in the early 60s. Strange as it might seem, until the 1950s, land and other resources were regarded as infinite in Canada. The realization of the falsity of this assumption motivated the Federal Government of Canada to commission a national inventory of land and other resources in 1963-64. The project was named Canadian Geographical Information System (CGIS); with the aim of producing data, statistics and information that could be relied upon to develop land management plans for effective resources utilization. This necessitated the development of techniques for rapid handling and analysis of large volumes of data and numerous maps generated from the exercise. Today, there are many commercial GIS packages, and techniques of GIS have become more robust and institutionalized in ecological monitoring and environmental management.

The advent of GIS may be regarded as a singular event with perhaps the greatest potential for altering the shape of ecology since the technique has a unique feature of enabling the detailed spatial representation and rapid manipulation of geographical data on computers. It must be stressed that GIS emerged at a critical time when ecologists were busy exploring the role of spatial structure on the dynamics of communities, population, and ecosystems. These were usually represented within spatial ecology, as entities having spatial relations with one another, besides the traditional ecological relations defined by their interactions (Kerr and Østrov, 2003). Prior to the development of GIS, tractable models required the idealization of uniform geometries even in individual-based models.
(Shugart et al., 1992); but the advent of GIS led to the replacement of this idealization with more veridical spatial relations. Although it may be argued that GIS-based ecological modeling is still in its infancy, it is no longer controversial that visual representation offers scientific innovations and resources not offered by purely linear representations. GIS also offers the opportunity of vectorising scanned images to produce raster ecological data in form of grids or tessellations with specific attributes. Such raster data can be obtained by remote sensing through satellite imagery from which the distribution of many ecological variables such as vegetation and soil types can be derived.

The fieldwork, on which all empirically sound ecological theory should presumably be based, is also plagued by a major problem called partial observability. The reason is that even the most basic parameters are often difficult to estimate accurately; hence some theorists argue that many ecological models are often difficult to test in the field. The problem of partial observability has to some extent been resolved by the panoramic view provided by remote sensing and analytical capabilities presented by GIS.

Unfortunately, mainstream scientists and traditional ecologists have so far paid little or no attention to the implications of GIS technology in the recent advancement of ecology as a field of science. Mr. Vice Chancellor Sir, there is a good news; the good news is that this is an area where my research has been profitably engaged for over two decades and the robust platform upon which my intellectual discourse has rested.
MANIFESTATIONS OF ECOLOGICAL HAEMORRHAGE IN NIGERIA

Since the earth was formed about 4.6 billion years ago, it has gone through many changes and its ecology has changed considerably over these many years. Changes in ecological regimes have first and second order effects on terrestrial ecosystems, on the air, and on the natural resources of the earth which made the earth habitable for man over the past centuries (Balogun and Salami, 1995).

Ecological haemorrhage occurs when an environment experiences loss of adaptive capacity due to perturbations which weaken the resilience of nature. This results in the degradation of environmental quality such as loss of soil fertility, increased temperature, declining rainfall, disease epidemics, famine, poor air quality, reduction of living space or arable land, deforestation, desertification, accumulation of toxic or non-degradable wastes, drought and other conditions that influence the well-being of people. The outcome is normally a crisis situation which reduces the quality of life and such ecological crisis may occur at varying scales (for example oil spill at local level and global warming at international level); or severity (depending on the degree of endemism); and length (ranging from a few months to several years). In describing the global ecological crisis, White (1967) refers to man's unnatural treatment of nature and its sad results. It was hypothesized that man's fire-drive method of hunting led to the emergence of grasslands, which helped to exterminate the monster mammals of the Pleistocene from much of the earth. This has not been proved and is unlikely to be true, but at least, one is tempted to think that the theory may be plausible after all, based on large-scale modification of
the natural environment orchestrated by man in the last five or six decades.

Unfortunately, human activities have exacerbated the ecological crisis in Nigeria (see Table 1), while the institutional capacity for combating the crisis remains weak. For instance, land-use change due to rapid urbanization, deforestation, agricultural practices and lots more affect the physical and biological properties of the land surface in the country. Such effects change the radiative forcing with potential impacts on the regional climate of Nigeria. The absence of safe water to over 50% of Nigerians is an indication that the public health is at risk from environmental pollutions and these constitute a major challenge facing the livelihood of people in Nigeria (Tayo-Alao, 2008). The population of Nigeria which was put at about 100 million in 1990s and 140 million by 2006 census, is predicted to exceed 200 million in the year 2100. To feed the burgeoning population, agriculture and livestock grazing have expanded correspondingly, often into marginal areas that are not ecologically suitable for such activities. Increased crop output has been achieved largely through expansion of cultivated area, with serious consequences for ecological sustainability.

As if to provide collateral damage to the ecologically fragile situation, major urban centres are growing even faster with growth rates of between two to three times those of the national population (Takatoshi, 2008); bringing with it myriads of environmental problems. In the far north, desertification which was estimated to be advancing at a rate of 0.6 km per annum in 1990s is now progressing at about 1 km every year. In the east, erosion has become a titanic ecological challenge and these gullies seem to be widening each year, with more budgetary allocation from the
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gressing at about 1 km every year. In the
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with more budgetary allocation from the

eytical fund. In the coastal areas, shoreline recession is estimated at a
rate of > 3m annually. The most significant case of coastal erosion is
recorded in Lagos. The erosion of Bar Beach threatens public and private
property, worth billions of Naira, on Victoria Island. Unsustainable oil
exploration with its frequent spillage, and monstrous gas flaring, which
destroy niches and habitats and threaten human survival in the Niger Delta
Region, has turned the area to a hot spot, where environmental activism
has created breeding ground for militants of dissident groups.

A Accumulated CO₂ emanating from gas flaring alone in Nigeria between
1990 and 2030, is projected to exceed 1858 million tonnes (Cohen and
Goward, 2004). Even government agencies such as the Niger Delta
Development Commission (NDDC) admitted in its report of 2005 that oil
and gas operation has not only caused degradation to the environment
within an extremely sensitive ecosystem and destroyed traditional
livelihood of the Niger Delta; but also the concomitant environmental
pollution has affected weather conditions, soil fertility, water resources,
habitats for wildlife and plant life, just to mention a few (Twunasi and
Merem, 2006). United Nations Environment Programme (UNEP) noted
that the cost of not taking the necessary steps to prevent environmental
degradation in Nigeria is estimated at $5.1 billion per year or about 15% of
Nigeria's Gross Domestic Product (Research Consortium on Africa,
2002). Such seemingly institutionalized negligence has turned the Nigerian
environment into an ecosystem which has graduated from severe stress to
an alarming ecological haemorrhage. In a recent survey of environmental
sustainability, Nigeria had an Environmental Sustainability Index (ESI) of
36.7 and was ranked 133rd out of 142 countries surveyed. Concerted
efforts in terms of corrective research and suitable policy are required to
change the situation.
Figure 1: A map of nine ecological zones in Nigeria

Figure 2: Geo-Political Zones of Nigeria
### Table 1: Nigeria's Geopolitical Zones and Ecological Challenges

<table>
<thead>
<tr>
<th>Zone</th>
<th>Overview</th>
</tr>
</thead>
</table>
| North West    | i. Constituent States: Jigawa, Kaduna, Kano, Kastina, Kebbi, Sokoto, Zamfara  
|               | iii. Annual rainfall: <600-1000 mm  
|               | iv. Mean annual temperature: 27- >28°C  
|               | v. Vegetation: Mixed leguminous woodland, Sudan savanna (mixed  
|               |   gombrateous woodlands), edaphic and biotic savanna  
|               | vi. Geological formations: Precambrian to Cambrian undifferentiated basement complex, older granite and undifferentiated metasediment;  
|               |   cretaceous sediment  
|               | vii. Soils: Highly ferruginous tropical soils on crystalline rocks and on  
|               |   sandy parent materials, undifferentiated ferruginous tropical soils;  
|               |   vertisols (of lithomorphic origin).  
|               | viii. Farming systems: Agro-pastoral millet/sorghum; irrigated;  
|               |   cereal-root crops mixed  
|               | ix. Agricultural produce: Millet, rice, cowpea, sorghum, groundnuts,  
|               |   sugar cane, cotton, cattle.  
|               | x. Minerals: Gold, limestone, columbite, cassiterite, clay, kaolin.  
|               | xi. Power generation: None  
|               | xii. Industrial production: Low  
|               | xiii. Number of Dams and reservoirs: 128  
|               | xiv. Area of forest reserves (forest plantations): 1,357,722 ha;  
|               | 52,779 ha.  

| North East    | i. Constituent States: Adamawa, Bauchi, Borno, Gombe, Taraba, Yobe  
|               | iii. Annual rainfall: <600 mm  
|               | iv. Mean annual temperature: 27- >28°C  
|               | v. Vegetation: Sudan savanna (mixed gombrateous woodlands),  
|               |   scrub vegetation (shrub), edaphic and biotic savanna.  
|               | vi. Geological formations: Mixtures of undifferentiated basement  
|               |   complex, older granites, tertiary sediments and coastal plain sands  
|               |   Chad formations  
|               | vii. Soils: Mixtures of undifferentiated ferruginous; highly ferruginous  

Table 1 Contd.

<table>
<thead>
<tr>
<th>Major Ecological Challenges</th>
<th>North Central</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dam, salinity, disease transmission, air pollution, solid and liquid wastes, climate change effects.</td>
<td>i. Constituent States: Benue, Kogi, Kwara, Nassarawa, Niger, Plateau.</td>
</tr>
<tr>
<td></td>
<td>iii. Annual rainfall: 800–1400 mm</td>
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<tr>
<td></td>
<td>iv. Mean annual temperature: &lt; 22 – 28°C</td>
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<tr>
<td></td>
<td>v. Vegetation: Mixed leguminous woodland, Secondary forest</td>
</tr>
<tr>
<td></td>
<td>vi. Geological formations: Precambrian to cambrian undifferentiated basement complex, older granite and undifferentiated metasediment; cretaceous sediment; quaternary alluvium</td>
</tr>
<tr>
<td></td>
<td>vii. Soils: Mixtures of undifferentiated ferrisols; highly ferruginous tropical soils on crystalline rocks and on sandy parent materials; hydromorphic and halomorphic soils; vertisols (of lithomorphic origin)</td>
</tr>
<tr>
<td></td>
<td>viii. Farming systems: Cereal-root crops mixed; highland temperate mixed; root crops</td>
</tr>
<tr>
<td></td>
<td>ix. Agricultural produce: Maize, yam, sweet potatoes, sorghum, cotton, cattle</td>
</tr>
<tr>
<td></td>
<td>x. Minerals: Barite, columbite, wolframite, tantalite, mica, talc, coal, gold, zinc, marble, kaolin, iron, clay, lead, iron</td>
</tr>
<tr>
<td></td>
<td>xi. Power generation: Hydro</td>
</tr>
<tr>
<td></td>
<td>xii. Industrial production: Low to moderate</td>
</tr>
<tr>
<td></td>
<td>xiii. Number of Dams and reservoirs: 115</td>
</tr>
<tr>
<td></td>
<td>xiv. Area of forest reserves (forests, plantations): 2,842,475 ha</td>
</tr>
<tr>
<td>Pollution, solid and liquid wastes, climate change effects.</td>
<td>vili. Farming systems: Pastoral, agro-pastoral millet and sorghum and cereal root crops</td>
</tr>
<tr>
<td>ix. Agricultural produce: Millet, groundnuts, sugar cane, cotton, cattle</td>
<td></td>
</tr>
<tr>
<td>x. Minerals: Trona, limestone, diatomite, bentonite</td>
<td></td>
</tr>
<tr>
<td>xi. Power generation: None</td>
<td></td>
</tr>
<tr>
<td>xii. Industrial production: Low</td>
<td></td>
</tr>
<tr>
<td>xiii. Number of dams: 28</td>
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</tbody>
</table>
### Table 1 Contd.

<table>
<thead>
<tr>
<th>South West</th>
<th>South East</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Major Ecological Challenges:</strong></td>
<td><strong>Major Ecological Challenges:</strong></td>
</tr>
<tr>
<td>Solid and liquid wastes, acid rain, air pollution, deforestation, floods including coastal floods, dam failure, disease transmission, biodiversity loss, climate change effects.</td>
<td>Erosion, air pollution, deforestation, disease transmission, solid and liquid wastes, biodiversity loss, climate change effects.</td>
</tr>
<tr>
<td><strong>South West</strong></td>
<td><strong>South East</strong></td>
</tr>
<tr>
<td>Constituent States: Ekiti, Lagos, Ogun, Ondo, Osun, Oyo</td>
<td>Constituent States: Abia, Anambra, Ebonyi, Enugu, Imo</td>
</tr>
<tr>
<td>Annual rainfall: 1400-3000 mm</td>
<td>Annual rainfall: 1400-2800 mm</td>
</tr>
<tr>
<td>Mean annual temperature: 26 - 27°C</td>
<td>Mean annual temperature: 26 - 28°C</td>
</tr>
<tr>
<td>Vegetation: Forest-savanna mosaic, secondary forest, swamp, strand.</td>
<td>Vegetation: Forest-savanna mosaic, secondary forest, swamp.</td>
</tr>
<tr>
<td>Geological formations: Precambrian to Cambrian undifferentiated basement complex, granite and undifferentiated metasediment; alluvium and coastal plain sands; cretaceous sediments.</td>
<td>Geological formations: Alluvium and coastal plain sands; cretaceous and tertiary sediments.</td>
</tr>
<tr>
<td>Soils: Highly ferruginous tropical soils on crystalline rocks; ferrallitic soils of deep porous brown soils on sandy materials; hydromorphic soils such as marine and coastal soils.</td>
<td>Soils: Ferrallitic deep porous brown soils on sandy materials and reddish-yellow gravelly soils on crystalline acid rocks; hydromorphic riverine soils.</td>
</tr>
<tr>
<td>Farming systems: Root crops, tree crops and coastal artisanal fishing.</td>
<td>Farming systems: Root and tree crops.</td>
</tr>
<tr>
<td>Agricultural produce: Cassava, maize, yam, cocoa, oil palm, cashew nuts.</td>
<td>Agricultural produce: Cassava, maize, yam, rice, oil palm, plantain, cashew nuts.</td>
</tr>
<tr>
<td>Minerals: Gold, limestone, talc, kaolin, glass sands.</td>
<td>Minerals: Coal, limestone, lead, zinc, clay, bricks, petroleum.</td>
</tr>
<tr>
<td>Power generation: Thermal</td>
<td>Power generation: Thermal</td>
</tr>
<tr>
<td>Industrial production: High</td>
<td>Industrial production: Moderate</td>
</tr>
<tr>
<td>Number of Dams and reservoirs: 41</td>
<td>Number of Dams and reservoirs: 115</td>
</tr>
<tr>
<td>Area of forest reserves (forest plantations): 1,045,633 ha (8.65% ha)</td>
<td>Area of forest reserves (forest plantations): 51,206 ha (16.04% ha)</td>
</tr>
</tbody>
</table>

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- **Beneke, Kogi, Kwara, Nassarawa, Niger, Plateau**
  - 06: 20,266,257
  - 800-1100 mm
  - Temperature: <22 - 28°C
  - Mixed leguminous woodland, Secondary forest
  - Vegetation: Precambrian to Cambrian undifferentiated granite, older granite and undifferentiated metasediment; alluvium, quaternary alluvium
  - Soils: Un diferentiated ferrisols, highly ferruginous crystalline rocks and on sandy parent materials; halomorphic soils. Vertisols (of lithomorphic origin)
  - Cereal-root crops mixed; highland root crops
  - Agriculture: Maize, yam, sweet potatoes, sorghum.
  - Barite, columbite, wolframite, tantalite, mica, marble, kaolin, iron, clay, lead, iron, hydro.
  - Agriculture: Low to moderate
  - Reserves (forest plantations): 2,842,475 ha
Table 1 Contd.

| South South | i. Constituent States: Akwa-Ibom, Bayelsa, Cross-River, Delta, Edo, Rivers |
| | iii. Annual rainfall: 2000->3000 mm |
| | iv. Mean annual temperature: 26-27°C |
| | v. Vegetation: Mangrove forest, swampland, secondary forest, mixed woodland, grassland, savanna, desert. |
| | vii. Soils: Hydromorphic marine, coastal and riverine soils, Ferrallitic deep porous brown soils on sandy materials and reddish-yellow gravely soils on crystalline acid rocks and sandstone. |
| | viii. Farming systems: Tree crops, root crops, coastal artisanal fishing. |
| | ix. Agricultural produce: Cassava, maize, yam, rice, oil palms, plantain, cocoa. |
| | x. Minerals: Limestone, glass sands, petroleum, natural gas. |
| | xi. Power generation: Thermal |
| | xii. Industrial production: Moderate |
| | xiii. Number of Dams and reservoirs: 5 |
| | xiv. Area of forest reserves (forest plantations): 1,227,539 ha (197,031 ha) |

Source: Salami, et. al. (2009)

MY RESEARCH FOCUS AND CONTRIBUTIONS: SO FAR STILL FAR...

Mr. Vice Chancellor Sir, the journey to this podium started well over four decades ago.

Born in Ibadan (a metropolitan city in Southwestern Nigeria), I had my primary education in the countryside by a combination of providence and destiny. My closeness to nature in my early childhood triggered my keen interest in the understanding of natural environment. As a child living in a
traditional African village during the formative years of life, I was able to observe the complex interactions between the physical and cultural environment in the serene milieu of inviolate rurality. Eventually, I developed interest in pursuing my career in the area of rural-urban landuse dynamics and environmental problems resulting from human development in Nigeria. By providence I had opportunity for UNDP funded specialized training in remote sensing and Geographical Information Systems, and this has since changed the orientation of my research. As a young researcher during a period tagged oil boom in Nigeria, I developed interest in the topical issue of sustainable development, based on the understanding that the development pathway in my country may not be sustainable in the long run. My motivation was based on the fact that there is a need to seek a development approach that is economically feasible (before the advent of global economic meltdown); ecologically sustainable (prior to the ecological crisis now staring us in the face); and socially desirable (to avoid the kind of social upheaval currently going on in the restive Niger Delta). I started my career as a Teaching Assistant in the Department of Geography in 1987. The interdisciplinary nature of my research interest prompted me to seek employment in the Institute of Ecology and Environmental Studies (the first academic establishment of its type in the entire West Africa sub-region), which is also the multidisciplinary and trans-disciplinary platform for teaching and research in this University. I joined the Institute in 1991 as a “recruit outside the mainstream of traditional ecologv” with a Master of Science Degree in Geography and professional qualification in remote sensing applications. By the grace of God, within a space of 12 years, I rose through the system to be promoted to the rank of Professor in 2003, (7 years after completing my PhD programme), and was appointed the first Director within the Institute in 2006.
My approach of investigation has been based on a combination of the traditional field survey methods and remote sensing techniques as well as Geographical Information Systems (GIS). Through scholarship and grantmanship, I established the Space Applications and Environmental Science Laboratory (www.spaeloauife.net). This laboratory was the first fully equipped GIS laboratory in this University (apart from RECTAS) and has been awarding postgraduate fellowship to students and staff of this University on an annual basis since it was established. This is my own modest contribution towards the required capacity building, with respect to equipping students and researchers with requisite skills in the applications of remote sensing and GIS required for diverse and/or complex environmental analysis and ecological management. It is also borne out of my belief that nobody will be remembered for what he has done for himself, no matter how noble. We can only be remembered for what we have done for others.

My research efforts received a boost from numerous grants obtained and collaboration fostered with several national, regional and international organizations such as National Space Research and Development (NASRDA), Federal Ministry of Science and Technology, Nigerian Maritime Administration and Safety Agency (NIMASA), Federal Ministry of Transport, Federal Ministry of Environment, National Centre for Remote Sensing, Jos, International Institute for Geo-Information Science and Earth Observation, Enschede, The Netherlands, International Secretariat of System Analysis for Research and Training (START) - International Geosphere-Biosphere Programme (IGBP), Washington DC., UNESCO Intergovernmental Oceanographic Commission, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), University of The Gambia, Gambia,
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and GIS required for diverse and/or
and ecological management. It is also
likely will be remembered for what he has
valuable. We can only be remembered for

University of Dar es Salaam, Tanzania, International Centre for
Theoretical Physics (ICTP), Trieste, Italy, Ramboll Natura AB, Sweden and
International Steering Committee for Global Mapping (ISCGM), Japan
among others.

Landuse Dynamics, Trend of Deforestation and Climate Change
Climate is a complex system that is controlled by the atmosphere, the
oceans, the cryosphere and the land surface which are permanent features
of the earth. These features are under continuous influence of human
activities. There is currently a widespread concern about changes in
climate at various scales and implications of those changes for life on this
planet Earth. The concern is not much on the natural changes in climate
but on the changes which may be brought about by human activities.

A number of evidences have been gathered to show that there is a steady
increase in greenhouse gases (GHG) due to man’s industrial and
agricultural activities which is capable of initiating spatio-temporal
variations in climate (Ramanathan, 1988). This has triggered off some
remarkable changes in climate which has been a subject of concern that
needs continuous monitoring and documentation. In Nigeria, just like in
most other African countries, rainfall is the only parameter available with
continuous data sufficient to infer climate changes during the instrument
era of many researchers (Adejuwon et. al., 1990; Tyson, 1993). But the
landuse pattern over the years has triggered off some changes in the
rainfall regime.

The marked decline in precipitation in relation to increasing latitude which
correlates to the distance from the coast (r=0.85) originates from the
southwesterly equatorial, the so-called monsoonal, moist and cool air
masses following the northern track of the Inter-Tropical Convergence Zone (ITCZ) in the wet season (Kowal and Knabe, 1972). Hence the increasing aridity of the Northern Nigeria cannot be properly understood or modeled without a proper understanding of the nature of the dynamics of tropical rainforest in the Southwestern part of the country.

Nigeria is one of the countries with an extensive coverage of tropical rainforest which has been described as one of the global commons. According to World Resources Institute (2003), forest/woodlands originally covered about 45% of the Nigerian landmass some 8000 years ago, based on the current climatic conditions. But by 2000, the tropical forest and woodlands covered only about 15% of the country’s landmass. On the global scale, the rate of tropical deforestation is not known with any accuracy, but is estimated by the Food and Agriculture Organisation (FAO) as around 15.4 million ha per year. Its destruction has many serious long-term environmental implications and hence there is need for proper monitoring of this invaluable resource.

Several studies in Southern Nigeria (Salami, 2000a; Salami, et. al., 2000; Salami and Aladenola, 2003; Salami, et. al., 2004) have shown that areas previously characterized by a continuous cover of forest are being converted to secondary regrowth vegetation, mainly as a result of intermediate shifting cultivation and lumbering. Climatologists argue that the declining precipitation in the Sudan zone is caused by diminishing water transport of the monsoon (Fricke, 2004). It has been noted that decrease in precipitation in the Sahel and Sudan savanna zones of northern Nigeria is a result of a disturbance of the atmospheric circulation south of them. About 60% of the water content in the clouds in the middle and northern Nigeria originates from evapotranspiration of the humid
track of the Inter-Tropical Convergence (Kowal and Knabe, 1972). Hence the northern Nigeria cannot be properly understood without understanding of the nature of the dynamics of the western part of the country.

Trees with an extensive coverage of tropical forests described as one of the global commons. Forests Institute (2003), forest/woodlands of the Nigerian landmass some 8000 years ago and conditions. But by 2000, the tropical forest only about 15% of the country’s landmass. Such deforestation is not known with the Food and Agriculture Organisation (FAO) year: Its destruction has many serious consequences and hence there is need for proper forest management.

Salami, 2000a; Salami, et. al., 2000; Egbio, et. al., 2004) have shown that areas with a continuous cover of forest are being converted to pasture and as a result of deforestation, deforestation and lumbering. Climatologists argue that deforestation is caused by diminishing access to timber (Fricke, 2004). It has been noted that the Sahel and Sudan savannas zones of northern Nigeria have experienced the atmospheric circulation south of the equator in the middle and from evapotranspiration of the humid rainforest and the adjacent semi-humid rainforest (Zheng and Eltahir, 1998). Meteorological records of Maiduguri (near Lake Chad) show over 20% decrease in precipitation between 1905 and now while isohyets have shifted more than 100 km south for the period 1949-1961. This fits into the general picture of climate change in West Africa as discussed by previous researchers (Olajiran, 1999; Nicholson et. al., 2000).

The effect of deforestation is not only in terms of declining rainfall in the north, but the exposed surface arising from deforestation leads to increased run-off rate and reduced evapotranspiration in the south. This reduces the amount of water available for atmospheric circulation. The resulting increase in atmospheric dust prevents the rain-producing monsoonal winds from moving north. Opening up the tropical rain forest results in significant disruption of the soil-vegetation system (Tables 2 & 3). This vegetation modification is visible in southwestern Nigeria, because the forests are never allowed to recover (Salami, 1995; 1998).

The value of forest cover loss in Nigeria (based on Total Cost Accounting procedure i.e. TCA) is now estimated at $750 million annually. The World Bank also estimated the value (in terms of avoided costs) of forest cover, which protects and regulates soil, water, wildlife, biodiversity, and carbon fixation, at over $5 billion annually in Nigeria. Adequate measures are therefore required to manage the remaining forest in a sustainable manner and this should be integrated into climate change programme for the country.
Table 2: Mean values, standard errors and index of change of vegetation parameters in Ife and Ede regions as compared with mature forest (Control) and the student's t-test and ANOVA F-Ratios

<table>
<thead>
<tr>
<th>Vegetative variable</th>
<th>Ife region</th>
<th>Ede region</th>
<th>Mature forest</th>
<th>t-value</th>
<th>Change index (%)</th>
<th>ANOVA F-ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(A)</td>
<td>(B)</td>
<td>(Control)</td>
<td>(A)</td>
<td>(B)</td>
<td></td>
</tr>
<tr>
<td>Foliage cover %</td>
<td>78.0±1.9</td>
<td>69.4±2.1</td>
<td>100±5.0</td>
<td>11.76**</td>
<td>27.87**</td>
<td>9.57**</td>
</tr>
<tr>
<td>Tree density (trees/ha)</td>
<td>730.0±6.6</td>
<td>448.0±5.6</td>
<td>922.0±6.9</td>
<td>5.71**</td>
<td>7.64**</td>
<td>21.50**</td>
</tr>
<tr>
<td>Tree girth (cm/Tree)</td>
<td>0.7±0.1</td>
<td>0.4±0.2</td>
<td>0.9±0.3</td>
<td>0.83*</td>
<td>18.40**</td>
<td>8.37**</td>
</tr>
<tr>
<td>Basal area (m²/ha)</td>
<td>22.0±0.4</td>
<td>9.0±0.6</td>
<td>32.1±1.2</td>
<td>1.30*</td>
<td>2.17*</td>
<td>57.7</td>
</tr>
<tr>
<td>Volume of wood (m³/ha)</td>
<td>235.2±2.5</td>
<td>96.7±4.5</td>
<td>507.5±4.3</td>
<td>1.92*</td>
<td>2.10**</td>
<td>84.9</td>
</tr>
<tr>
<td>Height of emergent layer (m)</td>
<td>35.0±2.5</td>
<td>24.1±1.1</td>
<td>41.5±2.4</td>
<td>1.55*</td>
<td>5.75**</td>
<td>16.3</td>
</tr>
<tr>
<td>Canopy crown frequency (%)</td>
<td>1.8±0.7</td>
<td>0.3±0.1</td>
<td>6.8±0.9</td>
<td>7.87**</td>
<td>7.92**</td>
<td>73.5</td>
</tr>
<tr>
<td>Understory crown frequency (%)</td>
<td>41.0±4.9</td>
<td>9.9±3.2</td>
<td>24.0±4.2</td>
<td>6.87**</td>
<td>6.91**</td>
<td>-70.96**</td>
</tr>
<tr>
<td>Understory crown frequency (%)</td>
<td>57.2±4.3</td>
<td>89.0±3.4</td>
<td>69.2±4.1</td>
<td>3.50**</td>
<td>10.65**</td>
<td>17.4</td>
</tr>
<tr>
<td>Number of species (per ha)</td>
<td>77.4±2.9</td>
<td>69.4±2.1</td>
<td>176.0±4.9</td>
<td>2.03*</td>
<td>2.18*</td>
<td>56.0</td>
</tr>
<tr>
<td>Simpson index of species diversity</td>
<td>0.5±0.2</td>
<td>0.7±0.3</td>
<td>0.9±0.2</td>
<td>2.54*</td>
<td>2.25*</td>
<td>46.4</td>
</tr>
</tbody>
</table>

*This shows percentage increase compared with mature forest rather than decrease.

$t_{st}$ (98) = 1.99

$F_{st}$ (98) = 2.64

$F_{st}$ (2;152) = 3.00

Source: Salami, 1998
<table>
<thead>
<tr>
<th>Soil properties</th>
<th>Ife region</th>
<th>Ede region</th>
<th>Mature forest</th>
<th>Ife region</th>
<th>Ede region</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field moisture capacity (FMC) (%)</td>
<td>7.5 ± 0.3</td>
<td>6.3 ± 0.2</td>
<td>10 ± 0.8</td>
<td>15.0</td>
<td>37.5</td>
</tr>
<tr>
<td>Organic matter content (%)</td>
<td>2.7 ± 0.4</td>
<td>2.6 ± 0.2</td>
<td>4.1 ± 0.8</td>
<td>24.2</td>
<td>36.6</td>
</tr>
<tr>
<td>Available phosphorus (ppm)</td>
<td>27.4 ± 2.9</td>
<td>12.4 ± 2.3</td>
<td>27.5 ± 2.5</td>
<td>0.4</td>
<td>51.4</td>
</tr>
<tr>
<td>Nitrates - Nonorganic (ppm)</td>
<td>29.5 ± 4.9</td>
<td>20.5 ± 3.1</td>
<td>29.4 ± 5.3</td>
<td>0.4</td>
<td>30.2</td>
</tr>
<tr>
<td>pH (CaCl₂)</td>
<td>5.7 ± 0.4</td>
<td>5.1 ± 0.2</td>
<td>6.1 ± 0.6</td>
<td>7.2</td>
<td>13.5</td>
</tr>
</tbody>
</table>

*Negative sign implies higher value in Ife region than in mature forest.

Source: Salami, 1998
Nigeria has been actively involved in climate change issues. For instance, the country is involved in Clean Development Mechanism (CDM) and is a signatory to the United Nations Framework Convention on Climate Change (UNFCCC), which gives guidance for addressing the greenhouse gases (GHGs) in the atmosphere. However, attention has not been given to specific issues that could assist in climate change control and adaptation. For example, historical data (such as land use, forestry, biomass stock, etc) that are essential variables for either climate change modeling or monitoring climatic variations on a continuous basis are either not available or found in an unorganized and uncoordinated format. The country, until recently, depends on the rates of deforestation produced by international organizations such as FAO and World Bank which are sometimes conflicting (depending on the source) and generally do not reflect the reality on ground. Most of the landuse maps produced by these international organizations such as FAO or International Steering Committee for Global Mapping (ISCGM), are nothing more than broad generalizations which are not usually in tandem with local realities and are therefore of little use to local authorities for planning purposes. My empirical studies (Salami, 1999; Salami et al., 1999; Salami, 2000b; 2006a; 2006b) based on satellite data suggest that both the global and national estimates being quoted for Nigeria by these international agencies are under-estimated. The main reason is that these maps are usually generated from secondary or surrogate data without field validation.

Mr. Vice Chancellor Sir, I have made some remarkable contributions on the trend of deforestation in Nigeria and its implications for climate change monitoring or ecological management in the country. Specifically, my work was the first to provide empirical rates of deforestation in Nigeria from
ved in climate change issues. For instance, the Development Mechanism (CDM) and is a Framework Convention on Climate change, guidance for addressing the greenhouse emissions. However, attention has not been given in climate change control and adaptation. Such as land use, forestry, biomass stock, etc) for either climate change modeling or on a continuous basis are either not available or uncoordinated format. The country, until 1990 of deforestation produced by international and World Bank which are sometimes source) and generally do not reflect the landuse maps produced by these such as FAO or International Steering Group (ISCGM), are nothing more than broad usually in tandem with local realities and are not authorities for planning purposes. My 1999; Salami, 2000b; 2006a; Salami et al., 1999; Salami, 2000b; 2006a; Salami et al., 2000b; 2006a; Salami 2008a; 2008b; Salami and Balogun, 2004; Salami, 2008a; 2008b).

Ecological Competition on the Forest Fringes

The boundary area of the humid tropical rainforest zone is an area of great ecological relevance. Consequently, these transitional areas have been the subject of a long series of ecological studies in Nigeria. These studies (e.g. Morgan and Moss 1965; Adejuwon et al. 1989) have focused mainly on the spatial analysis of the biotic and edaphic components of the environment. The temporal aspect has not been fully emphasized in the published works, yet this aspect has many ecological implications which have been documented in literature. Some of my studies (Salami, 1999; Salami, 2000b) were therefore devoted to the spatial and temporal...
monitoring of vegetation with remote sensing techniques on the fringes of
Nigeria's rainforest, for the purpose of landuse planning and rational
environmental management. This research approach was unique in
Nigeria as at the time it was initiated because, high spatial-resolution
satellite data were used in conjunction with multi-date aerial photos of the
same area. The combined use of aerial and space data is a result of the
non-availability of high resolution satellite data for the early dates (1960s
and 1970s), and the fact that the area has not been covered by aerial
photographs since 1975.

The satellite data revealed that the nature and intensity of cultivation
within the tropical forest zone have resulted in occurrence of vegetation
similar in form to savanna within the forest belt (Fig. 3). It was found that
extensive occurrence of burnt patches on the forest fringes (as shown on
the satellite imagery) might continue to encourage the downward shift of
the savanna boundary in the area because many studies (e.g. Clayton 1958,
Charter and Keay 1960), have shown that constant burning of tree cover
results in the replacement of forest communities by a new biota called
derived savanna. Poor edaphic and biotic management techniques may
reinforce the savanna elements in the ecological competition in the area.

In addition, the nature of forest-savanna boundary has been a subject of
intellectual argument in Nigeria. While some (e.g Morgan and Moss, 1965)
maintained that the boundary is sharp, others (e.g. Hopkins, 1974;
Adejuwon and Adesina, 1988) suggested that it is gradual. The species
ordination carried out to supplement image analysis supports the view
that the forest/savanna boundary is rather sharp as there was sharp
transition from the sites of forest to savanna species around the origin of
Remote sensing techniques on the fringes of the ordination plane (Ekanade, et. al., 1996). Thus, I have been able to characterize the various ecological groups within the Nigeria's rainforest belt (Salami, 2001) while the prototypes of vegetation profile for each of these groups were generated (Figures 4-9).

The nature and intensity of cultivation have resulted in occurrence of vegetation in the forest belt (Fig. 3). It was found that patches on the forest fringes (as shown on the map) encourage the downward shift of because many studies (e.g. Clayton 1958, show that constant burning of tree cover can lead to new biota called and bionics management techniques may help the ecological competition in the area.

The savanna boundary has been a subject of much discussion (e.g. Morgan and Moss, 1965) is sharp, others (e.g. Hopkins, 1974; suggested that it is gradual. The species diversity is rather sharp as there was sharp transition to savanna species around the origin of.
Ca - Citrus aurantium  Bc - Theobroma cacao  Cac - Cola acuminata  Eg - Elaeis guineensis

Figure 4: A typical profile of tree cropland in Nigeria's rainforest belt

Legend

<table>
<thead>
<tr>
<th>Size</th>
<th>Trees</th>
<th>Shrubs</th>
<th>Herbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>m</td>
<td>1</td>
<td>&gt; 10 m</td>
<td>&lt; 0.5 m</td>
</tr>
<tr>
<td>1</td>
<td>&gt; 25 m</td>
<td>0.5-2 m</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>&gt; 4 m</td>
<td>0.5-2 m</td>
<td></td>
</tr>
</tbody>
</table>

T  Woody plants (trees)
S  Shrubs
H  Herbs (nonwoody erect plants including grasses)

Ne - Newbouldia leavis  Fc - Ficus asperifolia  Cc - Capsicum annum  Mu - Mallotus subulatus
Fa - Funtumia africana  Da - Sida acuta  Ec - Chromolaena odorata

Figure 5: A typical profile of fallow land in SW Nigeria (see Fig. 4 for legend)

Az - Abizia zygia  Pu - Microdesmis puberula  Pc - Triplochiton scleroxylon  Cp - Ceiba pentandra
Cc - Melia excisa  Ne - Newbouldia leavis  Ac - Acridocarpus Sp. Du - Diospyrus miobuttensis
Ep - Terminalia superba

Figure 6: A typical mature forest in SW Nigeria (see Fig. 4 for legend)

Source: Salami (2001)
Pr- Piliostigma reticulatum  Az- Albizia zygia  Cl- Celtis intergrifolia  Sn- Spondias mombin  Fa- Funtumia africana  Ao- Alchornea Sp.  Cp- Ceiba pentandra  Pp- Penisetum purpureum  
Figure 7: A typical profile of ecotonal communities in SW Nigeria (see Fig. 4 for legend)

Fc- Ficus capensis  La- Lophira lanceolata  Ce- Canavalia ensiformis  As- Annona senegalensis  
Figure 8: A typical profile of savanna vegetation in SW Nigeria (see Fig. 4 for legend)

Dr- Delonix regia  Fa- Funtumia africana  Az- Albizia zygia  
Cm- Cynometra mollis  Pb- Pachystel brevipes  Fe- Ficus exasperata  
Eg- Eloeis guineensis  Db- Diospyrus monbuttensis  Cs- Ceiba pentandra  
Figure 9: A typical profile of secondary regrowth in SW Nigeria (see Fig. 4 for legend)

Source: Salami (2001)

**Figure 10:** Incursion into forest reserve in SW Nigeria  
**Source:** Salami et. al. (1999)
Forest Reserve Incursion

In 1949, forest reserves occupied about 7% of Nigeria’s land area and 15% of the areal coverage of the then Western Region of Nigeria (Nigerian Environmental Study/Action Team, NEST, 1992). Generally, these reserves are protected by legislation against agricultural activities and human occupation. Already, some parts of these reserves are being colonized for agricultural development by peasant farmers (Fig. 10). This development has far-reaching ecological implications. This issue has not been given due attention by the policy makers while adequate attempt has not been made by researchers and environmentalists to quantify the biotic degradation consequent upon the incursion. My work was the trail blazer in this regard in Nigeria, as some efforts were made to assess the extent of the incursions into forest reserves in Nigeria with alarming results (Figures 11-14).

The mode of incursion into the forest reserve in Southwestern Nigeria is mainly through agroforestry and arable cropland (Salami, et. al., 1999). This finding confirms the view of World Bank (1991) that most of the tropical forest cleared each year, is due to agricultural practices. It also lends credence to the hypothesis that deforestation is largely due to extensification of agriculture, involving clearing the land of substantial part of the forest reserves (Bilsborrow, 1994). Although agroforestry has been noted to be similar in its appearance to the forest ecosystem (Adejuwon and Ekanade 1988), its cover closure is obviously not the same as mature or high forest. This is because of the fact that cultivated plots need to be weeded regularly and this increases the openness of the land which may affect the ground surface albedo.
In 1986, the extent of road networks within Oluwa Forest Reserve for instance, was 52.27Km and it was confined to settlement areas as analysed from the images (Salami, 2008a). However, the information extracted from the 2002 satellite data showed that some roads had been constructed within the forest reserves, which increased the total length of the roads to 134.00 km. The logging routes being used by loggers which were 24.53 km in 1986, increased to 84.9 Km in 2002 (Table 4). The relationship between road access and deforestation is particularly strong in southern part of Omo, north of Oluwa and around Shasha forest reserve areas. Logging roads provide opportunity for farmers to enter the mature forest areas; where land is plentiful and cheap (Witte, 1992). It has been observed that loggers are often the first outsiders to penetrate tropical moist forest, leading to further degradation when farmers use logging roads to enter previously undisturbed forest and selectively degrade the area to establish temporary or permanent farms.
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infined to settlement areas as analysed
However, the information extracted
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often the first outsiders to penetrate
further degradation when farmers use
ly undisturbed forest and selectively
porary or permanent farms.

Figure 11: Southwestern Nigeria showing Oluwa Forest Reserve (1986 and 2002)
Figure 12: Satellite images showing significant changes in forest reserves
(The green colour shows areas where forest is intact)

Figure 13: Forest reserve in Southwestern Nigeria 1986 (top) and 2002 (below)
Figure 14: Road network for 1986 (top) and 2002 (below) in Oluwa forest reserve
Source: Salami, 2008a
Table 4: Length of different types of road in 1986 and 2002 within Oluwa forest reserves

<table>
<thead>
<tr>
<th>Types of Road</th>
<th>Road Length (in Km)</th>
<th>Decrease/increase in percentage (%)</th>
<th>Annual Decrease/Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feeder Road</td>
<td>27.73</td>
<td>49.10</td>
<td>+ 77.06</td>
</tr>
<tr>
<td>Logging Road</td>
<td>24.53</td>
<td>84.9</td>
<td>+ 246.11</td>
</tr>
<tr>
<td>Total</td>
<td>52.27</td>
<td>134.00</td>
<td>156.36%</td>
</tr>
</tbody>
</table>

Source: Salami, 2008a

It is clear from the findings that the government policy which declares forest reserves as an inviolate and a protected environment is not being properly implemented in Nigeria. Otherwise, large-scale incursion into forest reserve by the peasant farmers in the country would not have been possible. There is, therefore, the need to support environmental policy statements in Nigeria with appropriate policy implementation, monitoring and evaluation strategies. It is necessary to improve the ability of local people to act in an environmentally sound way, before the governments in the developing countries can successfully discourage the exploitation of natural resources in a way that maximizes short-term profit (Sachs, 1992; Akinwumi, et. al., 2001). The reasoning behind this is that poverty alleviation is the only feasible or ethically tenable means of protecting natural areas in the long run (Ryan, 1991; Salami, et. al., 2000).

The results of this study call for a closer supervision of forest reserves in South-western Nigeria. Otherwise, uncontrolled human activities may rob the entire South-western Nigeria of the species refuge and genetic bank required to maintain an acceptable level of elasticity, amplitude and floristic stability of the region.

The findings suggest that in a country like Nigeria with a poor data bank, and where aerial photographic products are not readily available on a
regular basis, the combined use of high resolution satellite imageries and aerial photos provides a suitable tool for environmental monitoring. For instance, the original boundary of the forest reserve was clearly shown on the imagery. The boundary was very sharp because exotics were planted on the hedgerows of the forest reserve in the area. The exotics were planted at specified intervals leading to the trees being evenly spaced. These hedgerows were still left intact by the local farmers despite their incursions into the reserves. This accounts for the strong angularities discernible on the imagery.

**Industry and Environment**

The impact of manufacturing and extractive industry has also engaged my attention. I have provided empirical data on the extent of vegetation and soil degradation occasioned by mining activities in Southwestern Nigeria. There is evidence of contamination of soil and plant species with trace metals, capable of impacting negatively on human health. For instance, we established that cement dust deposition had both visible and physiological impact on the vegetation around Ewekoro. Since the deposition lowered the chlorophyll synthesis significantly, then, the primary productivity of the area was found to be lower than that of cement-dust-free-environment (Salami, et. al., 2002). It was however established that the impact of cement dust deposition on plants was limited to a distance of about 5km from the factory site. Plant diversity (H') was highest at a distance of 6 km from the factory site; after this point, there was little change in the species diversity farther away from the factory site. The correlation co-efficient between tree density and distance from the factory was 0.7, suggesting a linear relationship between the two. The regression plot from tree density was generated \(Y = 94.89 \div 13.75X \) and is significant \((P \leq 0.05)\).
of high resolution satellite imagers and tool for environmental monitoring. For the forest reserve was clearly shown on very sharp because exotics were planted in reserve in the area. The exotics were adding to the trees being evenly spaced. intact by the local farmers despite their his accounts for the strong angularities

An extractive industry has also engaged myriads of data on the extent of vegetation and mining activities in Southwestern Nigeria.ation of soil and plant species with trace gatively on human health. For instance, we position had both visible and physiological id Ewekoro. Since the deposition lowered tantly, then, the primary productivity of the an that of cement-dust-free-environment however established that the impact of nts was limited to a distance of about 5km ivity (H') was highest at a distance of 6 km point, there was little change in the species e factory site. The correlation co-efficient ance from the factory was 0.7, suggesting a e two. The regression plot from tree density 3.75X and is significant (P < 0.05).

In Itagunmodi area, it was noted that though the entire area is under secondary forest, gold mining is exacerbating the problem of vegetation degradation (Salami, et. al., 2003). A comparison of the woody species density on the mine site with the control plot is a clear testimony to this (Tables 5 & 6). This is with the attendant effect on species diversity and richness as well as structural characteristics of the vegetation. The result of the litter cover and standing crop of litter in the study area further confirms the impact of mining on vegetation. It should be noted that estimates of litter fall can provide information on production, decomposition and nutrient cycling in ecosystems.

Mining in the area produces high quantities of wastes in form of tailings which constitute a significant source of metal contamination in soils in the vicinity of mining sites. The trace elements are locked up in the mine wastes and in the soil; they undergo oxidation through weathering reactions, which results in the metal ions becoming distributed within the soil system and hence potentially bioavailable. The situation depicted in our study portends serious health implications for humans in the area. Plant species (Manihot esculenta, Cola nitida and Elaeis guineensis and others), analysed in our study are of economic importance in the area, either for consumption or processing into a consumable product. When those plant species parts or products containing high concentrations of trace elements, are consumed by animals and man, they are assimilated, with serious consequences for the health of humans and animals. For example, the Pb contents in cassava tubers and oil palm in the study area are much higher than the FAO/WHO guideline of 0.3μg/g. Cassava is a popular Nigerian staple widely eaten either raw or more commonly when processed, while oil palm is a major source of edible oil in the country.
It was suggested that miners back-fill and revegetate the burrow pits, trenches and excavations arising from mining activities. Moreover, appropriate bio-remediation programmes should accompany mining operations in the area.

<table>
<thead>
<tr>
<th>Site</th>
<th>Trace metal concentrations (mg kg⁻¹ dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currently under mining</td>
<td>pH 6.9a 2.54ab 0.1jc 40.08a 137.27b</td>
</tr>
<tr>
<td>Mine degradation</td>
<td>Pb 3.80a 0.29a 24.00b 181.08a</td>
</tr>
<tr>
<td>Mine and abandoned with</td>
<td>Cd 2.54ab 0.21a 25.00b 102.17c</td>
</tr>
<tr>
<td>deforestation</td>
<td>Hg 1.29b 0.25a</td>
</tr>
<tr>
<td>Unmined (control)</td>
<td>Fe 22.000</td>
</tr>
</tbody>
</table>

Table 3: pH and Trace Metal Concentrations of Soil Samples in Ilagunmodi

Values are means of three replicates. Means in the same column followed by the same letter are not significantly different at

P = 0.05 according to Duncan's Multiple Range Test.

Sources: Salami et al. (2003)
back-fill and revegetate the burrow pits, arising from mining activities. Moreover, programmes should accompany mining

<table>
<thead>
<tr>
<th>Plot</th>
<th>Plant</th>
<th>Part</th>
<th>Pb</th>
<th>Cd</th>
<th>Hg</th>
<th>Fe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currently under mining</td>
<td>Cola nitida</td>
<td>Leaves</td>
<td>3.43</td>
<td>1.62</td>
<td>15.67</td>
<td>235.00</td>
</tr>
<tr>
<td>Mined and Abandoned with forest degradation</td>
<td>Theobroma cocco</td>
<td>Leaves</td>
<td>3.28</td>
<td>1.17</td>
<td>25.33</td>
<td>170.33</td>
</tr>
<tr>
<td>Mined and Abandoned with forest degradation</td>
<td>Mansifera erecta</td>
<td>Leaves</td>
<td>2.05</td>
<td>0.98</td>
<td>20.48</td>
<td>130.33</td>
</tr>
<tr>
<td>Mined and Abandoned with forest degradation</td>
<td>Crinum jagus</td>
<td>Leaves</td>
<td>2.05</td>
<td>0.57</td>
<td>63.63</td>
<td>1165.67</td>
</tr>
<tr>
<td>Unmined (control)</td>
<td>E. guineensis</td>
<td>Leaves</td>
<td>3.52</td>
<td>0.31</td>
<td>50.20</td>
<td>621.67</td>
</tr>
</tbody>
</table>

Source: Salani et al. (2003)

Table 7: Sources of energy for cooking in Ilexa, a secondary urban centre

<table>
<thead>
<tr>
<th>Fuel type</th>
<th>Normal sources</th>
<th>Alternative sources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Respondents</td>
<td>%</td>
</tr>
<tr>
<td>Electricity</td>
<td>19</td>
<td>1.69</td>
</tr>
<tr>
<td>Gas</td>
<td>23</td>
<td>2.05</td>
</tr>
<tr>
<td>Kerosene</td>
<td>1012</td>
<td>90.12</td>
</tr>
<tr>
<td>Wood</td>
<td>69</td>
<td>6.14</td>
</tr>
<tr>
<td>Charcoal</td>
<td>0.00</td>
<td>434</td>
</tr>
<tr>
<td>No alternative</td>
<td>0.00</td>
<td>0.09</td>
</tr>
<tr>
<td>Total</td>
<td>1123</td>
<td>100.00</td>
</tr>
</tbody>
</table>

*Not applicable

Source: Salani et al. (1997)
Forest-Energy-Environment Triad

The lack of a coherent overall energy pricing policy has brought about anomalies and distortions in fuel pricing. A survey of households was carried out in Ilesa, a secondary urban centre in south-western Nigeria in 1995 (Salami, et. al., 1997). Respondents were asked to state the main source of energy for cooking and the alternative source used when the main source was not available. The results (Table 7), show that kerosene is the main energy source with about 90% of the population depending on it for cooking. However, whenever it is not available or unaffordable, 60% of the inhabitants utilized fuelwood. For example, the Agala forest located within the city of Ibadan (in South-western Nigeria) was largely deforested when the citizens were unable to obtain kerosene during the political crisis of 1994 (Akinbami, et. al., 1996). This underscores the impact that dependence on fuelwood can have on the forest cover in the country. Dependence on fuelwood in the rural centres where approximately 70% of Nigerians live is much higher.

In terms of Net Emission (i.e. sum of delayed emissions and prompt emissions less the uptake for a particular year), the total carbon released from the Nigerian forest was estimated to be 9.5 Mt carbon (Mt C) in 1990. Projected carbon emission at the current level of economic activities, using a modest 1.3% per annum deforestation rate will increase from 9.5 Mt C per annum in 1990 to about 15.9 Mt C per annum in 2030, while at a deforestation rate of 2.6% per annum emission are expected to increase from 9.5 Mt C per annum in 1990 to about 26.5 Mt C per annum in 2030 which is about a three-fold increment.

We have proposed a holistic strategy for managing the forest-energy-
Energy pricing policy has brought about pricing. A survey of households was ban centre in south-western Nigeria in ondents were asked to state the main the alternative source used when the results (Table 7), show that kerosene is at 90% of the population depending on it it is not available or unaffordable, 60% of . For example, the Agala forest located western Nigeria was largely deforested obtain kerosene during the political crisis (6). This underscores the impact that was diring the country, rural centres where approximately 70%

Table 8: Proposed strategy for sustainable forest-energy interactions in Nigeria

<table>
<thead>
<tr>
<th>Option</th>
<th>Basis</th>
<th>Time</th>
<th>Region</th>
<th>Targeted sector/ income group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small scale</td>
<td>Decentralised system hence can be used in grid electricity to the wide geographic regions of the country and remote areas, highly consistent with national environmental and development goals, high potential for CO₂ reduction, high direct benefit/cost ratio, highly sustainable and has high societal acceptability, high potential for CO₂ reduction, high indirect economic impacts: high direct benefit/cost ratio, highly sustainable, highly consistent with both national environmental and development goals, and will be highly acceptable to the society.</td>
<td>Long term</td>
<td>All regions</td>
<td>Isolated rural people from the national grid</td>
</tr>
<tr>
<td>Improved</td>
<td>Kerosene is the major cooking fuel and even lighting fuel, during electric shortages in the urban sector, although it does not rank high in most of the criteria for screening as revealed by Table 8, however it is highly sustainable and will be highly acceptable to the society.</td>
<td>Short term</td>
<td>All regions</td>
<td>Urban poor and the rural populace</td>
</tr>
<tr>
<td>Improved</td>
<td>Kerosene is the major cooking fuel and even lighting fuel, during electric shortages in the urban sector, although it does not rank high in most of the criteria for screening as revealed by Table 8, however it is highly sustainable and will be highly acceptable to the society.</td>
<td>Shortmedium term</td>
<td>All regions</td>
<td>Urban</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>High direct benefit/cost ratio, consistent with national environmental goals, increases domestic employment.</td>
<td>Medium term</td>
<td>All regions</td>
<td>Rural and urban poor</td>
</tr>
<tr>
<td>Coal Briquettes</td>
<td>Absence of fuel, can easily use in existing and use device which is also portable</td>
<td>Medium term</td>
<td>All regions</td>
<td>Urban</td>
</tr>
<tr>
<td>Solar PV</td>
<td>Decentralised system and can be used in remote areas for power from the national grid to accelerate rural electrification</td>
<td>Medium long term</td>
<td>All regions</td>
<td>Rural sector and medium income urban dwellers</td>
</tr>
<tr>
<td>A mixture of</td>
<td>No single option can efficiently enhance sustainability in the various ecological zones of the country</td>
<td>Short term</td>
<td>All regions</td>
<td>Urban</td>
</tr>
</tbody>
</table>

Note: Short term implies <5yr; medium term implies 5-10yr, long term implies >10yr.

Source: Akinbami et al. (2003)
Mangrove and Wetland Ecology

Mangroves all over the world are of interest to environmental managers and researchers alike, as mangroves occupy wetlands which constitute part of what is referred to as world’s ecologically sensitive zones. Mangroves occur within the area between the coastline and inland. In Nigeria, it has been noted that inlets along the Nigeria-Cameroon coast characterized by long wave energy regime and sediment accretion have provided a suitable habitat for the development of structurally complex mangrove vegetation (Ukpong, 1997). The vegetation consists of trees that are tolerant of high salinity (Walsh, 1974), tidal inundations (West, 1956), anaerobic sediments (Chapman, 1976) and long periods of rainfall. This unique ecosystem provides several valuable environmental functions. For instance, Wang et. al. (2003) noted that mangrove forests anywhere in the world, are irreplaceable feeding and Nursery grounds for many ecologically and environmentally valuable fish and shellfish as well as crustaceans like prawn and crab species; the trees recycle nutrients and trap land-based debris or suspended particulate matter, while the roots secure the land to prevent it from erosion.

It is important to be able to assess, monitor and manage mangrove zones on a sustainable basis, as its status is indicative of the health of the coastal region. The case of tsunami disaster in Asia whereby mangroves proved to be an effective barrier is a pointer to the significance of this unique ecosystem. The mangrove types and zonation, location, boundaries, area of clearance, coverage, stem density and species composition are the most important information required by coastal managers and scientists (Green et al, 2000). But the morphology of the mangrove zones makes it difficult to penetrate so as to obtain these parameters via ground survey.
of interest to environmental managers since wetlands which constitute important ecological zones. The development of structurally complex mangroves has led to the coastline and inland. Inlets along the Nigeria-Cameroon coast provide an example of the sediment accretion and mangrove zone in the Niger Delta area of Southern Nigeria. None of those few studies have focused on the role of remote sensing in mangrove assessment.

My research was the first to develop baseline database on the mangrove and wetland ecology in Nigeria (Salami and Balogun, 2005; Salami, 2006a; 2006b; 2008a) from medium resolution satellite images. The results show that the cover types could be grouped into 3 main types viz: wetland (consisting of mangrove swamp and degraded mangrove), the dry land (consisting of high forest and light forest) and others (consisting of water body and mudflat/bare surface).

The results obtained from the assessment indicate that medium resolution satellite images could be used to generate a baseline database for coastal environment monitoring. This could serve as a springboard for organized management of wetlands in Nigeria in particular, and West Africa in general. Extensive degradation of the mangrove forest as well as ubiquitous areas of clearance discernible on the classified images is an indication of the ecological haemorrhage which this habitat has been undergoing. This is supported by the result of the biodiversity survey of the area which reveals that 3 out of the 7 species in the study area had a frequency of less than 1% (Table 9). Further degradation without adequate assessment and management could endanger such species.

It is clear from the study discussed above that many of the parameters that...
are important for the assessment of the health of the mangrove zone can be derived from NigeriaSat-1 in a timely and resource effective manner, with reasonable accuracy levels. What is now required is the establishment of a remote sensing-based framework for database development, regular monitoring and sustainable management regime of this critical ecological habitat in the Nigerian coastal zone. Such an initiative could benefit from the experiences in Tanzania under the Tanzanian Mangrove Management Project (TCMP, 2001) and Coastal Regulation Zone (CRZ) in India (Nayak, 2004).
ment of the health of the mangrove zone can be monitored in a timely and resource effective manner, through the use of remote sensing-based framework for database management and sustainable management regime of the Niger Delta. Such an initiative has led to the development of a framework in Tanzania under the Tanzanian Coastal Management Programme (TCMP, 2001) and Coastal Regulation (2004).

Table 9: Species composition of mangrove zone in Southern Nigeria

<table>
<thead>
<tr>
<th>Tree Species</th>
<th>Family</th>
<th>Frequency (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Dalbergia melanoxylon</td>
<td>Leguminoseae-Papilioniodeae</td>
<td>7.59</td>
</tr>
<tr>
<td>2. Drepanocarpus lunatus</td>
<td>Leguminoseae-Papilioniodeae</td>
<td>0.51</td>
</tr>
<tr>
<td>3. Thespisia populnea</td>
<td>Malvaceae</td>
<td>0.75</td>
</tr>
<tr>
<td>4. Hyphaene thebaica</td>
<td>Arecaceae (Palmae)</td>
<td>3.03</td>
</tr>
<tr>
<td>5. Rhizophora racemosa</td>
<td>Rhizophoraceae</td>
<td>86.07</td>
</tr>
<tr>
<td>6. Syzygium guineense</td>
<td>Myrtaceae</td>
<td>0.51</td>
</tr>
<tr>
<td>7. Cassipoureae barteri</td>
<td>Rhizophoraceae</td>
<td>1.51</td>
</tr>
</tbody>
</table>

*Rhizophora racemosa* (Rhizophoraceae) in Mangrove Forest, Nigeria

Source: Salami and Balogun (2006)
Validation of NigeriaSat-1 Data

When NigeriaSat-1 was launched in 2003, it was saddled with the responsibility of validating its data for forestry applications. I subsequently conceptualized a research on Monitoring deforestation and implications for biodiversity monitoring in Nigeria using data from NigeriaSat-1 and other satellites; which attracted the sponsorship of National Space Research and Development Agency (NASRDA). The initiative was designed and executed as a nation-wide study covering four out of six geo-political zones viz: South-South, South West, North Central and North East.

The study in the South South (Salami and Balogun, 2005; Salami, 2006c) reveals that ecological datasets are derivable from NigeriaSat-1 with comparable accuracy to Landsat and ASTER. An overall accuracy of 78.13% was obtained for Landsat while it was 75% for ASTER and 71.9% for NigeriaSat-1. In the South West zone which represents the tropical rainforest belt in Nigeria, it was found that deforestation is progressing at the rate of 1.36% per annum. This is higher than the rate of 0.76% quoted for the country by UNEP (2006) and lower than the estimated rate of 3.5% being used by the Federal Department of Forestry, but falls within the rate of 1.0-1.5% given for the developing countries by World Bank. The results obtained from Guinea savanna and Sahel savanna ecological zones revealed a similar pattern. The Evergreen Woodland is declining at a rate of 4.3% per annum in the North Central zone while it is 4.1% in the North Eastern zone. The analysis also shows that the available volume of surface water is receding at a rate of 3.2% in the North Central zone while it is 3.8% in the North Eastern zone. The results of this study can therefore be related to the climate change issues in Nigeria. The findings
suggested in 2003, I was saddled with the task for forestry applications. I subsequently worked on Monitoring deforestation and monitoring in Nigeria using data from satellites, which attracted the sponsorship of the Development Agency (NASRDA). The study was a nation-wide study covering four zones: South-South, South West, North Central

s are derivable from NigeriaSat-1 with IENAC and ASTER. An overall accuracy of 55% while it was 75% for ASTER and 71.9% for the West zone which represents the tropical savanna and Sahel savanna ecological zone. The Evergreen Woodland is declining at a rate of 4.1% in the North Central zone while it is 3.2% in the North Central zone while the results of this study can facilitate change issues in Nigeria. The findings suggest that the declining water volume in the Northern Nigeria may be associated with progressive increase in the area coverage of Dry woodland and continuous decrease in the coverage of Evergreen woodland.

When the outputs of the study are compared with the country-wide exercise conducted by FORMECU in 1976/78 and 1993/95, it is evident that our work provides an improved mapping scheme, as well as finer and better details that could be used for planning purposes by the relevant authorities.

Implications for Climate Change Modelling

Significant uncertainties surround predictions of regional climate changes in general but predictive models rely on landuse data as part of the variables (Salami et. al., 2008b). Inaccurate landuse data therefore increases the unreliability of such models. Adaptation strategies are easier formulated when the future directions are known with a high level of certainty. Landuse pattern is indicative of future vulnerability to climate change as well as adaptive capacity of the society. Attention needs to be focused on feedback from landuse in Nigeria. This has been a major problem that requires urgent attention. My studies have demonstrated the significance of geo-information system in capturing and management of the required landuse data (Salami and Balarogun, 2004; Salami, 2006c; 2006d)

There is, therefore, a need for the development of a geo-spatial framework for historical data. This will ensure that climate change programme in Nigeria takes advantage of the recent development in satellite technology in the country (specifically with the launch of NigeriaSat-1). The aim of the proposed framework is to establish a
Geographical Information System (GIS) based GHG monitoring in Nigeria. This will assist Institutional Data Providers (IDP) with respect to stocktaking in future.

There is a global apprehension that a new kind of climate changes is now underway and that its impacts on people and ecosystems are likely to be drastic especially in the less developed countries. IPCC (2001) predicted a rise of 1.4 to 5.8°C in global mean surface temperatures over the next 100 years while temperature increases of about 0.2-0.3 °C per decade have been reported for Nigeria (Ojo, 1985; Olayanju, 1991). Human activities, such as clearing of tropical forests in Central and Western Africa, alter local climate and rainfall patterns and increase the risk of drought (FAO 2001). Specifically, experts have demonstrated that the natural vegetation destruction and degradation severely affects the microclimate, hydrological cycle, precipitation dynamics, albedo and energy budget of the atmosphere (IPCC, 1990).

The feedback from the landuse needs to be empirically investigated, documented and properly organized for regular update and monitoring. It is hoped that the implementation of the geo-spatial framework being proposed in this Lecture could help in enhancing the reliability of climate change models.

**Linking Research with National Policy**

One of the hindrances to development in the third world countries is the lack of appropriate linkages between policy thrust and research efforts or findings. Sustainable development will be a mirage except there is a bridge between the intelligentsia and policy makers. As a professor of
m (GIS) based GHG monitoring in Nigeria. Data Providers (IDP) with respect to
that a new kind of climate changes is now
on people and ecosystems are likely to be
dveloped countries. IPCC (2001) predicted a
temperature increase of about 0.2-0.3 °C per decade have
(1985; Olayanju, 1991). Human activities,
its in Central and Western Africa, alter local
increase the risk of drought (FAO 2001).
monstrated that the natural vegetation
severely affects the microclimate, on
dynamics, albedo and energy budget of
Environmental Management, I strive to respond to this challenge and my
efforts are already yielding fruitful results. In order to make the results of
my studies available to the policy makers, government and non-
governmental organizations, as well as all stakeholders at both the national
and international levels; and against the backdrop of the need to put
Nigeria in the network of nations that use satellite-based systems for
forest assessment, monitoring and management, an international
stakeholders' workshop on Geo-Information System-Based Forest
Monitoring in Nigeria (GEOFORMIN) was held in Abuja, in March 2006. It
is important to note that as at today, no Nigerian forest is being managed in
a sustainable manner and this has consequences for the Nigerian
economy; and undermines the efforts aimed at diversifying the Nigerian
economy as encapsulated in the National Economic Empowerment and
Development Strategy (NEEDS) document of the Federal Government,
hence the convocation of GEOFORMIN.

GEOFORMIN is a collaborative initiative involving Obafemi Awolowo
University (OAU); National Space Research and Development Agency
(NASRDA), the African Regional Centre for Space Science and Technology
Education English (ARCSTE-E); Regional Centre for Training in Aerospace
Surveys (RECTAS) and International Institute for Geo-Information Science
and Earth Observation (ITC), The Netherlands. The aim of the workshop
was to interact with the stakeholders at all levels with a view to articulating
the requirements for the utilization of NigeriaSat-1 for sustainable forest
management in particular and geo-spatial ecological database
development in general. The stakeholders agreed that follow-up advocacy
activities should be initiated, and encouraged at the states and local
government levels, to ensure attitudinal and policy changes that will lead to
the realization of an aspect of Chapter Seven of the NEEDS of the Federal
Government, which states that government strategic intent is to “utilize space-based research for environmental management”. It was also advocated that a geo-spatial landuse database should be established and updated from time to time.

Based on the outcome of GEOFORMIN workshop, I initiated a Roundtable discussion with researchers, technocrats, policy makers, Non-Governmental Organizations (NGOs), and Community-Based Organizations (CBOs); with a view to articulating a policy thrust on development of geo-spatial database for sustainable forest and desert management in Nigeria through a participatory approach. This was eventually hosted by the National Centre for Remote Sensing, Jos in November 2007, in collaboration with National Space Research and Development Agency (NASRDA); North East Arid Zone Development Programme; Department of Forestry, Federal Ministry of Environment; and Office of Surveyor General of the Federation.

The Action Plan articulated through this initiative includes Land use/land cover mapping of Nigeria at a scale of 1:100,000 which will be updated once in every 5 years. Subsequently, the Federal Government, through NASRDA inaugurated a Technical Implementation Committee in January 2008 to coordinate the initiative. A phased approach was adopted based on the six geo-political zones in Nigeria. It gladdens my heart to report that as I deliver this Lecture today, we have completed the work on the North Central zone while that of Southwestern zone is about to take off.

Recently, just about 4 weeks ago, I was selected (through a very stiff competition among distinguished nominees), as the only Nigerian for the
The government's strategic intent is to "utilize non-convivial management". It was also noted that the database should be established and maintained.

At the EOFORMIN workshop, I initiated a comprehensive policy framework to articulate a policy thrust on sustainable forest and desertification a participatory approach. This was followed by the Centre for Remote Sensing, Jos in collaboration with National Space Research and Development Agency (Nasarawa); North East Arid Zone Development Agency; Forestry, Federal Ministry of Environment; and the Federation.

Though this initiative includes land use/land at a scale of 1:100,000 which will be useful, the Federal Government, through the Technical Implementation Committee, adopted a phased approach to address the current situation. It gladdens my heart to announce that today, we have completed the work on that of Southwestern Nigeria zone is about to take place.

Some time ago, I was selected (through a very stiff screening process) as the only Nigerian for the prestigious Eisenhower programme (Philadelphia, USA) on "Fueling Growth". The programme identifies emerging leaders all over the world who have the potential to make an important contribution to their societies (Wolf, 2009). The fellowship offers unique opportunity to develop intense and rewarding exchange among professional counterparts all over the world and dialogue with highly accomplished Americans; under the leadership of notable Board members such as General Colin L. Powell (Rtd.), The Honourable George Bush, Henry A. Kissinger, Donald Rumsfeld, John Wolf and Madeleine K. Albright among others. Mr. Vice Chancellor Sir, this is another first in this University. It is my responsibility through this fellowship to liaise with the policy makers and technocrats in Nigeria on the development of renewable energy system in the country. This is not just another boost to my national and international visibility in the profession of environmental management, or an addition to my growing CV, it is indeed, a commitment to a lifetime of networking and working collaboratively with leaders sharing common interests and aspirations all over the globe, with a view to contributing to the solid profile of our University and projecting the image of our country positively.

CONCLUDING REMARKS

Mr. Vice chancellor Sir, There is increasing realization in the 21st century that technologies like remote sensing; Geographical Information System (GIS) and global positioning system (GPS) have immense potentials for providing key parameters required for ecological monitoring and sustainable environmental management (Salami et. al., 2007; Salami, 2008b). Together, these technologies form the basis of geospatial science (Murthy et. al., 2003).
The unique capability of satellite remote sensing of providing timely, repetitive and synoptic view over a large area has made it a very powerful tool for environmental managers in the 21st century. GIS serves to integrate spatial ecological information derived from remote sensing data and attribute data from all other sources to provide comprehensive geospatial database for regular ecological monitoring and sustainable environmental management. Recently, an initiative was launched by the United Nations on Reducing Emissions from Deforestation and Forest Degradation (REDD). In particular, REDD was highlighted in December 2007 by the Bali Action Plan adopted by the parties to the UN Framework Convention on Climate Change. All the programmes aimed at supporting REDD seek to foster the use of Earth observation satellites for estimating and verifying the status of, and trends in biomass and carbon content of forests (Achache, 2008). In this regard, the UN Group on Earth Observation (GEO) Secretariat has proposed the creation of a project for coordinating the national and regional activities that can feed into REDD. This therefore shows that geospatial science is being institutionalized at the global level as a pivot for sustainable environmental management, and any country that will be part of this global initiative must put space science applications on the front burner of its decision making process.

Unfortunately, the development of space science and its applications in ecological monitoring is still at its infancy in Nigeria.

Fortunately, recent developments in space science at national and international levels have now made it easier to utilize geospatial science for ecological management. On the international scene, there are now open source softwares (e.g. ILWIS) that can be obtained free of charge. Also, there is free Landsat programme through which the archived images may
Remote sensing is being institutionalized at regional activities that can feed into REDD. Geospatial science is being institutionalized at the UN Group on Earth Observation satellites for estimating trends in biomass and carbon content of forests. All the programmes aimed at supporting regional activities that can feed into REDD.

Recent figures show that the country is to derive maximum benefit from NigeriaSat-1. The rank of remote sensing experts trained in the 70s and 80s has been decimated by natural attrition and unstable government policies with no clear-cut succession plan in place. There is therefore a dire need to build technical capacity of the staff at the federal, state and local levels through training so that the staff can professionally manage and monitor the environment by drawing up ecological management plans. It is important to increase the technical capacity which will allow timely assessment of the ecological health or integrity of Nigeria; and increase the scientific capacity to analyze this information provided by NigeriaSat-1 or other satellites, and translate this to products useable at all levels for management and development purposes. This would empower the Federal Government of Nigeria to meet the obligations of a number of international Treaties and Conventions to which it is a signatory. However, I wish to emphasize that some recent efforts being made at the federal level can only succeed if the state and local governments appreciate the need for space-derived products for development purpose.

Nigeria has several agencies and parastatals with mandate on ecological and environmental protection or management. There, however, seems to...
be no clear-cut definition of functions, roles and responsibilities in some instances. This over-lap of functions has generated disagreement and resulted in frictions or muscle flexing, among these agencies while the environment continues to deteriorate. Government must make conscious efforts to improve the level of complementarities among these agencies and reduce duplication of functions.

Admittedly, the fiscal allocation at all levels of government has not matched the pace of ecological haemorrhage going on, but efforts must be made to ensure judicious use of statutory allocation through Ecological Fund Office in the Presidency. The fund was originally 1% of the Federation Account but this was reviewed upward to 2% in 1992. There is a need for the Ecological Fund Office, to encourage the relevant agencies to initiate proactive activities in all the ecologically sensitive areas, to ensure early detection of disasters. This is the key to effective ecological control and management. These should include community mobilization in recipient communities (Salami et. al., 2009). This mobilization will achieve two objectives. First, it will assist to determine the priority of proposed intervention projects vis-à-vis other ecological problems in the communities. Second, it will help to create awareness in such communities, for maximum acceptance and active participation in Ecological Fund’s priority intervention projects. We must accept the fact that it is only a combined effort by the government and the people in a unique and proactive manner that can stop the alarming ecological haemorrhage currently going in Nigeria.

The Ecological Fund Office should also work with research institutions such as Institute of Ecology and Environmental Studies of Obafemi
Awolowo University and experts in the field of ecology to facilitate some of its activities. This will strengthen the technical capability of the Ecological Fund Office in fulfilling its mandate.

A Tribute to My Roots

Every flowing river has a source no matter the number of its tributaries, and any river that disconnects with its roots is on its way to drying up. Permit me therefore to dilate very briefly about my roots in the academia before ending this once-in-a-lifetime Lecture.

Once upon a dispensation, geography was regarded as jack of all trades, as a geographer can aspire to be almost anything in the arena of intellectualism. This was then viewed as a weakness when it comes to focus or competitive advantage within the strict confines of traditional disciplinary playing field. That was the situation when everybody had exclusive control over his cheese and every gateway was securely protected by the gatekeepers. In this era of multi-disciplinary emphasis however, the broad-based training provided by geographic science has now become a virtue. This broad outlook at the foundation of my career has gone a long way in preparing me for the transdisciplinary challenge I have had to face, in the course of traversing the landscape of ecology; where everything relates to everything else. The solid background in geographic science and regional development has provided the wings for me to fly and I am eternally grateful to all those who nurtured me in the discipline, especially my PhD supervisor, who ensured that I was well cooked.
Towards the end of the last century, the gulf between the various fields of science began to narrow and new territories emerged within the existing disciplines. Competition paved way for complementarity as tiny disciplinary feeding bottles gave way for big multi-disciplinary food basket. This is the reality of the 21st century and we must all adjust to the fact that the old order has crumbled, with respect to the rigid compartmentalization of knowledge. The cheese is continuously moving away from the traditional stations and nobody can win a medal by asking why. Remote sensing probably becomes handy in tracking the trajectory of the cheese although getting at the cheese is a more complex procedure involving an interplay of scholarship, politics and faith. A thorough-bred geographer is however, strategically positioned to harvest fruits from these new fraternities. I dare say that this is a Unique Geographic Advantage (UGA)! I have attempted, in this Lecture, to present my academic score card within the short time that I have been in "circulation". Although the score card reveals my coat of many colours, I admit that there are still a lot to be done as I continue to navigate my way in the years ahead; God sparing my life. Nevertheless, based on my modest efforts with respect to the tripod upon which academic tradition firmly rests; namely scholarship, grantmanship and mentorship, it will not be immodest to claim that I have tried to put my UGA to productive use within the limited resources at my disposal and I can, at least, risk giving myself a tick in the margin.

Mr. Vice Chancellor Sir, I am aware that acknowledgement is not allowed in the Inaugural Lectures of this University. But it will be immoral for me to claim all the credits for the modest contributions I might have been able to make. Obafemi Awolowo University over the years has given me the
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sity over the years has given me the
platform for expression, as my divine station of achievements, and it is still
my God-given academic platform upon which I am standing today with an
absolute sense of fulfillment. I wish to place on record that all my degrees
were obtained in this great institution (OAU), justifiably called Oba Awon
Universities (i.e. the king of all Universities), but the products of my
research are very conspicuous in the international arena and are cited all
over the world. I am regularly inundated with requests for my products
and services from all geographic regions of the globe.

I have also been blessed with several graduate students and colleagues in
the Institute, who have been my co-travellers in my journey so far. The
love of my darling wife and understanding of my children have been an
indispensable pillar of support all along. Above all, I owe everything to my
Lord Jesus Christ who is the Author and Finisher of my faith. It is in Him I
live, move and have my being (Acts. 17:28).

Mr. Vice Chancellor Sir, while thanking my audience, I found no better way
to end this Lecture than chorusing:

Now, Unto the King Eternal, Immortal, Invisible, The only wise
God, be the Honour and Glory and Forever, Ever (Amen) 2ce.

God bless you all.
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